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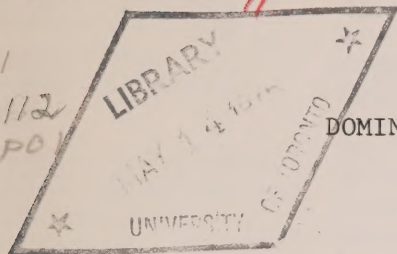
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COMPOSITION OF PUERTO RICO, 1950-60

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Leroy O. Stone

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Net Migration and the
Sex-Age Composition of
Puerto Rico, 1950-60*

Leroy O. Stone
Dominion Bureau of
Statistics

La migration est sans doute
le facteur explicatif principal
du changement de la
composition de la population
de Porto-Rico selon l'âge et
le sexe entre 1950 et 1960.
Grâce à son influence sur l'âge
de la population, elle
contribua indirectement à la
baisse du taux brut de la
natalité et à la baisse du taux
brut de la participation des
hommes à la main-d'oeuvre.

From 1950 to 1960 a high rate of net migration was observed from the island of Puerto Rico to the United States mainland. This article attempts to measure the effect of net migration on the sex-age composition of the population of Puerto Rico in that decade. The principal result is the indication that migration was probably the most important of the demographic processes in determining the changes in the sex-age composition of the Puerto Rican population during this period. In the light of this indication, an additional effort is made to gauge the indirect influence of net migration on the crude birth rate and on the crude rate of male participation in the labour force.¹

The relative influence of net migration on changes in the sex-age composition of a population, a relatively undeveloped area of demographic analysis,² is worth study because of the substantive significance of such changes. Great changes in the sex-age composition of a population tend to have important demographic, economic, and social implications.³ For this reason there is value in empirical studies which are designed to determine the relative importance of the components of age distributional change. The findings of such studies should eventually be synthesized into a body of fundamental generalizations concerning the functions of the mechanisms underlying changes in sex-age composition in different social, economic, and demographic conditions.

The important effects of a high rate of net emigration on the demographic structure of a population result from the well-known tendency for migration to be selective with

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¹The crude rate of male participation in the labour force is a rough measure of the rate of economic activity in the male population. It is defined as the percentage in the labour force among males aged 14 and over, and all relevant figures in this article refer to the civilian population. "Labour force" is defined in the Appendix. For discussions on the labour force concept and on associated problems of measurement see Gertrude Bancroft, *The American Labor Force* (New York, 1958), Appendix C; and A. J. Jaffe and Charles D. Stewart, *Manpower Resources and Utilization* (New York, 1951). No results are presented for the female labour force because of pertinent deficiencies in the census data for it. Cf. Leroy O. Stone, "The Recent Decline of the Female Labour Force Participation Rate in Puerto Rico," a paper presented at the 1965 meetings of the Population Association of America in Chicago; and A. J. Jaffe, *People, Jobs and Economic Development* (Glencoe, 1959), Appendix A.

²In contrast, the analysis of age distributional changes in closed populations is now well advanced. Cf. Alvaro Lopez, *Problems of Stable Population Theory* (Princeton, 1961).

³For related discussion see United Nations, Department of Economic and Social Affairs, *The Aging of Populations and Its Social and Economic Implications* (New York, 1956).

respect to such population characteristics as sex and age. The changes in population composition which are due to a high rate of net emigration can have ramifications on the crude birth rate, on the crude rate of economic activity, on the ratio of dependents to economic producers, on the occupational structure of the working force, and on the growth of particular consumer markets, among other variables.

Consider, for example, some probable effects of a high decade rate of net emigration on the age composition of a population. The immediate result tends to be a marked decline in the proportion of the population aged 20-34, a decline due largely to the tendency, reported in various studies of migration,⁴ for age-specific decade rates of net migration (whether in or out) to be highest in the cohort aged 10-24 at the beginning of the decade in question. During the course of the decade this cohort passes through the peak ages of family formation, fertility, and entry into the working force. No other age cohort⁵ makes a larger contribution to the total number of births over the decade, and a high net emigration rate among this cohort at the beginning of the decade may precipitate a fall in the crude birth rate. Such a fall tends, in turn, to increase the average age of the population and may affect the ratio of dependents to economic producers. A high rate of net emigration in this cohort may also promote a decline in the crude economic activity rate.

These results do not, however, follow invariably from net emigration, because, in general, the impact of net emigration on the demographic composition of a population depends on the level of the net emigration rate, on the duration of a high rate, and on the degree to which the net migration is selective of population characteristics. In addition, the economic ramifications of changes in demographic composition depend on the structure of the economy in question, on the rate of economic growth, and on the rate and occupational structure of unemployment, among other factors. None the less, an empirical study of the determinants of sex-age compositional changes contributes to analyses of the above-mentioned interrelations.

Net Intercensal Emigration from Puerto Rico

Net migration from Puerto Rico to the United States mainland between the 1950 and 1960 censuses of population is estimated at 352,400 for persons born on the island and residing there in 1950 (see Table I). This figure is 16 per cent of the island-born population of Puerto Rico in 1950, and is a relatively high rate of net emigration. It accounts for much of the sharp decline observed in the decade rate of population growth. In contrast to an increase of 18 per

⁴*Cf.* Hope T. Eldridge and Dorothy Swaine Thomas, *Population Redistribution and Economic Growth, United States: 1870-1950*, vol. III (Philadelphia, 1964).

⁵By "other age cohort" we mean one that is aged less than ten or greater than 25 at the beginning of the decade.

cent in the population from 1940 to 1950, there was an increase of only 6 per cent from 1950 to 1960, the population growing from 2,211,000 in 1950 to 2,350,000 in 1960. Ninety-nine per cent of the 1950 population consisted of persons born on the island.

Table I

Estimates of Net Intercensal Migration* for Island-Born Puerto Ricans Aged Ten and Over in 1960, by Sex and Selected Age Groups: Puerto Rico, 1950-60

Age Group in 1950	1950 Island- Born Population (A)	Estimated Net Migration (B)	Net Migration Rate (B/A)100
Males			
0- 9	341,500	-48,300	-14
10-19	245,900	-67,500	-27
20-34	231,100	-48,900	-21
35-64	239,500	-14,600	-6
65 & over	40,600	-500	-1
total	1,098,600	-179,800	-16
Females			
0-9	333,400	-50,800	-15
10-19	242,000	-63,600	-26
20-34	246,500	-41,100	-17
35-64	223,200	-16,500	-7
65 & over	44,300	-600	-1
total	1,089,400	-172,600	-16
Total	2,188,000	-352,400	-16

*See the Appendix for definition of the migration estimate. Sources: United States Bureau of the Census. *United States Census of Population: 1960, General Population Characteristics, Puerto Rico*, Final Report PC(1)—53B, 1961, Tables 18 and 28. *United States Census of Population: 1960, Detailed Characteristics, Puerto Rico*, Final Report PC(1)—53D, 1963, Table 75. *United States Census of Population: 1960, Subject Reports: Puerto Ricans in the United States*, Final Report PC(2)—ID, 1963, Table 1. *United States Census of Population: 1950*, vol. II, Part 53: Puerto Rico, 1952, Tables 37 and 41. *United States Census of Population: 1950* vol. IV: *Special Reports*, Part 3, chapter D: Puerto Ricans in Continental United States, 1953, Table 2.

In its relatively high rate of net emigration, the decade from 1950 to 1960 may turn out to be unique in the modern history of Puerto Rico. Migration from Puerto Rico was considerable after World War II,⁶ but it is reported that since 1960 there has been a reversal of the direction of migration between Puerto Rico and the United States mainland.⁷

⁶A. J. Jaffe, *People, Jobs and Economic Development*, p. 65.

⁷Cf. George C. Myers, "Migration and Modernization: The Case of Puerto Rico, 1950-60," a paper prepared for the 1965 World Population Conference in Belgrade.

Table I shows the estimates of net intercensal migration for persons born in Puerto Rico and residing there in 1950, as well as the net migration rates. The rate for each sex-age cohort is negative, indicating net emigration. The age profile of the rates has its peak in the 10-19 cohort, in which over 26 per cent of the 1950 island-born population of Puerto Rico is estimated to have been residing on the mainland in 1960. The estimates are based on the census survival ratio technique for measuring net migration, employing the 1950 and 1960 census populations (see the Appendix for precise explanation). Virtually all of the emigrants from Puerto Rico go to the United States mainland, and one set of estimates was therefore prepared from the enumerated residents of the mainland who were born in Puerto Rico. The census survival ratios were applied to the 1950 island-born residents of the mainland to obtain the population expected in 1960. The difference between the observed and the expected island-born residents of the mainland in 1960 is the estimated net migration. With the same set of survival ratios, another group of estimates was prepared using the enumerated island-born residents of Puerto Rico. The two sets of estimates correspond closely.⁸

The Influence of Net Emigration on Sex-Age Composition

This section presents the measurement of the relative contribution of net emigration to 1950-60 changes in the sex-age composition of the population of Puerto Rico. The age distributions of the male and female populations are treated separately, and the influence of net emigration on changes in the sex ratios by age is considered. Each age distribution of population and age schedule of sex ratios is a collection of ratios. For the change in each ratio within one of these collections, the influence of net emigration is measured, and an average of the measurements is defined. This is termed the average contribution of the net migration to observed changes in the ratios of the given collection. This is the procedure used in Table II, where we find that the net emigration from Puerto Rico accounts for an average of 46 per cent of each of the changes in the proportions which make up the age distribution of the male population. The figure of 46 per cent is obtained by reallocating the estimated net emigration by age to the 1960 male population of the island. This leads to a hypothetical age distribution: that which would have been observed in Puerto Rico in 1960 had the estimated net migration been zero at each age. By comparing the hypothetical and the observed age distributions a measurement is made of the influence of net emigration on the changes in the age composition of the male population. The details of this technique are shown in Table II.⁹

⁸Cf. Leroy O. Stone, "Some Demographic Aspects of Economic Changes in Sub-Regions of Puerto Rico, 1950-1960," unpublished doctoral dissertation, Department of Sociology, University of Pennsylvania, 1964, chapters 2 and 7.

⁹The unusually broad age grouping used in the 1950 census tabulations for Puerto Ricans residing on the United States mainland prevented the use of a more detailed age breakdown than that shown in Tables I and II.

Table II
Measurement of the Influence of Net Intercensal Migration on the Age Composition of the Island-Born Male Population of Puerto Rico, 1950-60*

Age Groups	1960 Observed (A)	1960 Hypothetical (B)	1950 Observed (C)	Change Due to Migration			Per Cent of Change Due to Migration ^a (G)
				Observed (A)-(C) (D)	(A)-(B) (E)	Change Unexplained (B)-(C) (F)	
0-9	29.9	26.9 ^b	31.1	-1.9	2.3	-4.2	35.4
10-19	25.2	24.9	22.4	2.8	0.3	2.5	10.7
20-34	16.8	20.7	21.0	-4.2	-3.9	-0.3	92.9
35-64	23.7	23.1	21.8	1.9	0.6	1.3	31.6
65 and over	5.1	4.4	3.7	1.4	0.7	0.7	50.0
Total	1,128,700	1,339,300	1,098,600		7.8 ^c	9.0 ^c	46.4 ^d

*All figures are percentages, with the exceptions of the three whole numbers in the bottom row. The sources are those given in Table I.

^aLet " x " refer to the change due to net migration and " y " represent that due to other variables. The per cent of the observed change which is due to net migration is defined as $([x]/[|x|+|y|]) \cdot 100$. Regardless of the signs of x and y , this percentage accurately reflects the relative arithmetical importance of these terms as determinants of the observed change.

^bThe net emigration of persons aged 0-9 in 1960 is estimated by the enumerated number of such persons who were born in Puerto Rico, but who resided on the United States mainland in 1960.¹⁰ This estimate is logically equivalent to a survival ratio estimate of net migration for the intercensal births. It is necessary to estimate the proportion aged 30-34 in 1960 among the net emigrants aged 30-44 (see Table I and footnote 9). In making this estimate it is assumed that the proportion was the same as that of the United States mainland population (males) born in Puerto Rico. It is also necessary to estimate the proportion aged 65-74 among the net emigrants aged 45-74 in 1960 (see Table I and footnote 9). Again, an assumption analogous to the foregoing is used.

^cThis is the sum of the entries in the column, disregarding their signs.

^dThis is equal to $7.8/(7.8+9.0)$, barring rounding error, and it is a weighted average of the entries in the column. See footnote a.

¹⁰The mixing of the enumerated population aged 0-9 in 1960 with the net intercensal migration for persons aged ten and over in 1960

(Continued)

The same technique as that used in Table II for measuring the relative importance of net migration on age distributional changes is also applied to the age composition of the island-born female population of Puerto Rico. The pattern is similar to that for the male population. The net emigration from Puerto Rico had its largest effect on the proportion of females aged 20-34, where it accounts for 98.9 per cent of the change. At the opposite end of the range, only 4.5 per cent of the change in the proportion of the population aged 10-19 is explained by the net emigration. On the average the net emigration accounts for 40.2 per cent of each of the age distributional changes. Similar measurement is applied to the distribution of sex ratios by age, and we find that the net emigration accounts for an average of 42.8 of each of the sex ratio changes.

On the whole, net emigration accounts for at least 43 per cent of the changes. This leaves at most 57 per cent to be explained by fertility, mortality, or random variation.

The pattern of major changes in the age composition of the entire population of Puerto Rico is, generally, similar to that shown by column D of Table 2, even though this column pertains only to island-born males. An age pyramid (by five-year age groups) has been constructed, and it shows sharp declines in the proportions for those aged 20-24, 25-29, and 30-34. Such declines are observed in both the male and the female populations, with the declines among males being slightly larger than those among females. In accounting for this pattern of age compositional changes, it would seem that migration was probably most important among the demographic processes.

Some Indirect Effects of the Net Emigration

Rough measurements of the indirect impact of the observed net emigration on the changes in the crude birth rate and in the crude rate of male participation in the labour force are given below. The observed net emigration appears to account for sizable percentages of the declines in both crude rates during the decade.

The technique of measurement is an application of the method of expected cases.¹¹ As was noted above, the estimated net emigration by sex and age can be added to the

is justifiable. The survival ratio estimate of net migration is logically equivalent to the surviving in-migrants minus the surviving out-migrants. The population aged 0-9 in 1960 is equivalent to a survival ratio estimate of net intercensal migration for the intercensal births. Cf. Leroy O. Stone, "An Analysis of Biases in the Major Estimates of Net Intercensal Migration," a paper prepared for the 1965 World Population Conference in Belgrade; Jacob S. Siegel and C. Horace Hamilton, "Some Considerations in the Use of the Residual Method of Estimating Net Migration," *Journal of the American Statistical Association*, XLVII (September, 1952), 475-500.

¹¹Some of the basic literature on this method is presented in A. J. Jaffe, *Handbook of Statistical Methods for Demographers* (Washington, 1951), chapter 3.

observed population to yield a hypothetical age distribution: that which would have been observed in 1960 if the net migration had been zero in each of the sex-age groups. By applying the appropriate proportions from the hypothetical age distribution to the 1960 age specific birth rates, we obtain a hypothetical crude birth rate: that which would have been observed in 1960 had the net migration been zero in each of the sex-age groups.¹² Similarly, it is possible to obtain a hypothetical rate of male participation in the labour force. For each of these rates, the difference between the hypothetical and the observed values is interpreted as a measure of the indirect impact of the net migration. Tables III and IV, which present the pertinent data, indicate that the net emigration accounts for 57 per cent of the change in the crude birth rate and for 64 per cent of that in the rate of male participation in the labour force.

Table III

Measurement of the Indirect Influence of Net Intercensal Migration on the Change in the Crude Birth Rate* of Puerto Rico, 1950-60

Age groups	Birth Rates ^a		Hypothetical distribution ^b (C)	(B)x(C)
	1950 (A)	1960 (B)		
10-19	46	42	123.4	5.2
20-34	252	229	114.2	26.2
35-49	84	61	75.6	4.6
Total	39	32		36.0 ^c

Crude birth rate change = 32 — 39

Relative contribution of net migration = $|32 - 36| / (|32 - 36| + |36 - 39|) = 57.1$ per cent.

*The "crude birth rate" is the total number of live births (for the indicated calendar year) per 1,000 population. An appropriate base for the crude birth rate is the mid-year population (for the calendar year in question), which is estimated by the census population in 1950 and 1960.

^aThe first three rows are the age-specific rates, the denominator in each case being the female population in the indicated age group. The last row contains the crude birth rates. The negligible number of births occurring to persons aged 50 and over were allocated to the 35-49 age group.

^bEach cell in this column gives the number of women in the stated age group divided by the total population (hypothetical), with the result being multiplied by 1,000.

^cThis is the hypothetical crude birth rate, and it is the sum of the other figures in the column.

The sources are given in Table 1, plus the following: United States National Office of Vital Statistics, *Vital Statistics of the United States: 1950*, vol. I, Table 11.09; United States National Center for Health Statistics, *Vital Statistics of the United States: 1960*, vol. I, Tables 4-7.

¹²Of course, the net migration may affect changes in the age-specific rates. In addition, other interactions between age distributional changes and age-specific rates cannot be ruled out *a priori*. However, data are seldom available for the measurement of these types of influence.

Table IV

Measurement of the Indirect Influence of Net Intercensal Migration on the Crude Rate of Male Participation in the Labour Force* of Puerto Rico, 1950-60. (Figures are percentages.)

Age Groups	Rates of Participation		Hypothetical Distribution	(B)x(C)
	1950 (A)	1960 (B)	(C)	
14-19	33.9	22.3	8.0	1.8
20-34	79.3	82.2	41.2	33.9
35-64	86.2	85.5	47.8	40.9
65 and over	44.9	27.6	3.0	0.8
Total	70.4 ^a	65.2 ^a		77.3 ^b

Change in the crude rate = 65.2 — 70.4

Relative contribution of net migration = $\frac{|65.2 - 77.3|}{|65.2 - 77.3| + |77.3 - 70.4|}$
= 63.6 per cent

Sources: United States Bureau of the Census. *United States Census of Population: 1950*, Tables 37, 41, and 58; Final Report PC (1)—53D, Table 96.

*The "crude rate of male participation in the labour force" is the percentage in the labour force among males aged 14 and over (see the Appendix).

^aThis is the crude rate.

^bThis is the hypothetical crude rate.

Conclusions

This analysis suggests that from 1950 to 1960 migration was probably the most important of the demographic processes explaining observed changes in the sex-age composition of the population of Puerto Rico. Through its impact on the age distribution, migration contributed indirectly to declines in the crude birth rate and in the crude rate of male participation in the labour force.

Appendix

The estimate of Net migration. The estimates of net intercensal migration which are shown in Table I were obtained by means of the census survival ratio technique. Let " $P_a(x, t)$ " refer to the population of place a which is aged x at time t . Let " $R(x)$ " be the proportion of $P_a(x, t)$ which survives ten years, that is up to time $t + 10$. Then the survival ratio estimate of net migration is defined as $P_a(x+10, t+10) - R(x)P_a(x, t)$.

In the present application of this estimate $R(x)$ is based on census data. $R(x)$ is estimated by obtaining the number of island-born persons aged $x+10$ in 1960 who were residing either on the United States mainland or in Puerto Rico. This number is divided by the corresponding population aged x in 1950. The estimate of $R(x)$ assumes that a negligible proportion of persons born in Puerto Rico resided in places other than the island or the United States mainland, an assumption which is generally accepted.

The census survival ratios are subject to the errors of enumeration and reporting typical of census data. However, this characteristic is, to some extent, fortunate because it tends

to induce the mutual cancellation of measurement errors in the net migration rate.¹³

It is known that survival ratio estimates of net migration are subject to inherent biases. The inherent bias in the census survival ratio estimate is equal to the difference between the intercensal deaths of emigrants and the intercensal deaths of immigrants. Of course, these estimates are insensitive to several migrations by the same individual, and return migration, because it is the sum of an emigration plus an immigration, makes a zero addition to net migration. None of these features of survival ratio estimates poses a significant problem when, as in this article, the migration estimates are used to measure population redistribution.¹⁴

Definition of the Civilian Labour Force. The labour force consists of the employed plus the unemployed. A civilian who is at least 14 years old is classified as employed, over a specified week, if (a) he is working for pay or profit, or (b) he does unpaid family work for at least 15 hours during the week, or (c) he has a job although he is temporarily absent from work. A civilian who is at least 14 years old is classified as unemployed, over a specified week, if he is not at work, and (a) is looking for work, or (b) is not looking for work *because* he is either ill temporarily, or is expecting to return to a job from which he has been indefinitely laid off, or if he believes no work is available.¹⁵

¹³For related discussion on this point see Everett S. Lee *et al.*, *Population Redistribution and Economic Growth, United States: 1870-1950*, vol. I (Philadelphia, 1957), chapter 1.

¹⁴There is now an extensive literature on defects in the conventional estimators of net migration. See, in particular, Everett S. Lee *et al.*, *ibid.*, and Jacob S. Siegel and C. Horace Hamilton, "Some Considerations in the Use of the Residual Method of Estimating Net Migration."

¹⁵*Cf.* United States Bureau of the Census, *Census of Population: 1950*, 53-IX.

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